Research Paper | Education | E-ISSN No : 2454-9916 | Volume : 6 | Issue : 9 | Sep 2020

# ONLINE SCIENCE LAB FOR SECONDARY SCHOOLS: A META ANALYSIS

Kirti Sharma

Ph.D Scholar, Institute of Advanced Studies in Education (IASE), Gujarat Vidhyapith, Ahemdabad, Gujarat, India.

## ABSTRACT

This study attempts to do Meta analysis of research done in past decade on application of online labs in secondary school education. Further, a comparison is drawn between existing online lab repositories for ease of teacher and students. All the articles and journals under study were peer reviewed and retrieved from free access sources like Google scholar and ERIC. The aim is to highlight the trend of research methods, research tool used as well as to draw opinion of teacher and students about efficiency of online lab. This research contributes in understanding impact of online labs as well as need of online lab repositories in secondary school education system.

**KEYWORDS:** Online lab, online lab repositories, secondary school science education.

## I. INTRODUCTION:

Learning process has seen a radical shift from teacher centered to student center in past few years. This is mostly because of insufficient opportunities for students to construct their own learning in traditional teacher centered method. The concept of "learning by doing" (Bruner, 1990) is not new and laboratories play a very important role in making science education student centered. However, in real world situation limited equipments, restricted time slots, large student groups are few factors which hinder the process of lab based learning.

However, technological advancement has given a new approach to lab based learning practices. World Wide Web has allowed change in physical laboratories and their partial substitution by online labs. OL's (Online lab) is term used loosely for defining of lab activities conducted by help of internet without the physical presence of instructor. In online labs more specifically virtual labs (VL) represent interactive environments for designing and conducting simulated experiments (Balamuralithara & woods 2009) and remote labs (RL) provides opportunity to collect data from real physical labs, including real equipments from remote locations (Gomes & Bogosyan 2009). Online labs recently have gained a lot of attention for providing support technology to science teachers for day to day lab based teaching.

Part of the motivation for this study comes from the real time problems in searching high quality online lab experience for students. Although there are many repositories which have online labs available on different subjects but it is still rare to find labs dedicated to secondary school curriculum. Many researches has been carried out in past decade either in area of developing repositories or on effectiveness of online lab based teaching in comparison to traditional methods. In present scenario a comprehensive review of impact of online labs in teaching learning process from both teacher and student perspective is essential. A systematic review will pave way for future of online lab repositories design as well as its overall effect on secondary school education system.

## II. FOCUS OF STUDY:

This paper aims to identify the research trends in online lab education especially for secondary school education from year 2010 to 2019. This paper also aims to identify scope of online lab repositories in school science education. The articles were reviewed on the lines of science subject under research, type of research, type of methodology used and research instruments used. Finally, the researcher reviewed various online repositories to identify whether metadata (a set of data which describes other data) used in them are of relevance for secondary school students and teachers or not. Finally, the researcher identifies the core areas where further work has to be done to strengthen usage of online science lab by secondary school students.

Based on the focus of this study, following research questions are addressed:

1. Which research method is most frequently used in these online lab centered research?
2. Which research instruments for data collection are most commonly used in these researches?
3. What is teacher and student take on use of online labs for science education?
4. Whether existing online labs repositories have used metadata relevant for secondary school students or not?
5. Which types of online labs are more frequent in these repositories (VL's or RL's)?

## III. RESEARCH DESIGN:

This study attempts to identify the direction of research in area of online lab based science education for secondary schools by thorough analysis of articles published in duration of 2010 to 2019 and is freely assessable. So, meta-analysis is the appropriate design for this study.

The most commonly meta-analysis is employed to understand changing trends in theoretical content and research methods by analyzing content of articles published in various journals. Loy and Pamela (1979). Thus meta-analysis specifically the critical review of previous research is employed to analyze 20 articles from open source online publications from 2010 and 2019 available in ERIC (Education Resource Information Center) and Google Scholar. The following factors were considered (i) year of publication (ii) authors, (iii) title of research (iv) objectives of research (v) methodology (vi) data analysis technique and (vii) summary of major findings.

Online lab repositories were identified by previous work (Zervas et al. 2014) as well as with the help of Google search with key words "online lab", "online science lab" and "online science lab repositories". The online lab repositories identified are then visited by researcher to understand and collect data of relevance for secondary school science curriculum.

## IV. RESULT AND DISCUSSION:

**Research methodologies applied in the articles:**

Research methodology is a procedure by which a researcher describes as well as proves a certain phenomenon (Rajasekar, Philominathan and Chinnathambi 2013). Quantitative, qualitative and mixed are the three types of main research methods. In the current study we have found that most employed research method in past ten years in area of online lab research is qualitative method (8 articles) followed by quantitative method (5 articles) and mixed research is least used (5 articles). Figure 1. Two articles by Diana Dikke et al 2014 and Christian et al 2010 is about synthesizing online lab repositories GOLABZ and Lab2go respectively. These two papers cannot be characterized in above three traditional research method types.

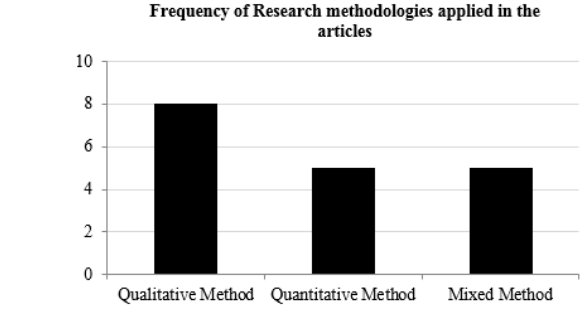


**Figure 1**

**Research tools used in the articles:**
Tools like questionnaire, interview, observation, test score etc are used in various research methods for collection of data from the sample. Many research articles have used more than one type of research instruments. In such cases each tool is counted separately and independently (Figure 2). The result suggests that most commonly used tool is questionnaire 11 (47.8%), followed by test score 8 (34.7%) and interview 3 (13%).

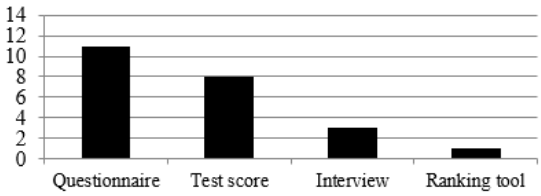


**Figure 2**

**Physics is a key research area in online lab platforms:**
Science as a subject can be broadly divided into three areas namely physics, chemistry and biology at least at secondary school level. In this study data revealed that out of all the online labs made available in last decade at various platform most of them were of physics (50.14% of total). Chemistry is at second place with 32.5% (Figure 3) and biology online labs are only 17.2% of total online labs made available in between 2010 and 2019.

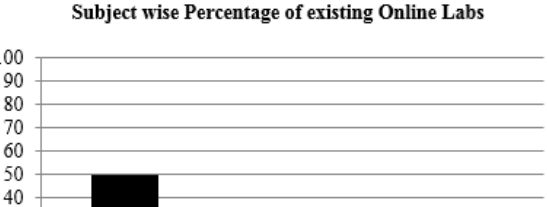


**Figure 3**

**Summary of major findings from the reviewed articles:**
This section provides major findings of the 20 reviewed articles of online labs from 2010 to 2019.

**Teacher's perspective on using online labs:**
There are two users of online labs; teachers and students. Teachers give insight about the pedagogy and relevance of the contents of online labs. In last ten years teachers have participated in various researches on online labs. Like 244 science teachers participated in survey conducted by Alijuhani et al (2018) and revealed that lack of time; high class strength and length of curriculum are the main problems in conducting experiments in school labs. 54.1% participant's believed that employing online labs in science education will enhance learning and 31.6% participants suggested that these online platforms will help teachers evaluate student's performance electronically. Same points are echoed by 90.48% of the 22 teachers of Ireland who participated in survey conducted by Ioana Ghergulescu in 2017. In addition, they have mentioned that students do have full access of computer labs and two third of participated teachers wanted to use more technology in classrooms. Instead of replacing classroom instructions completely by online lab Davenport et al (2018) found in interview with 14 teachers that learning is best when online labs are used for review of concepts. A small survey of two teachers by Jihad et al (2018) indicates that online lab platform like LabLesson helps in better visualization of experiments and are hazard free. Teachers in these reviewed articles also helped in creating better metadata for search for online labs in different repositories. For example, 82 European science teachers participated in study conducted by Zervas et al (2015) and stated that for online labs three most significant elements in finding appropriate lab from its repositories is subject domain, keywords and age range. In the reviewed paper teachers has positive approach in application of online labs. It helps teacher in better management of time with vast curriculum. It also helps in overcoming space and equipment restrictions while learning from labs.

**Students' perspective on using online labs:**
Students are the receiver of learning from online labs. In last decade almost every research done on online lab had a survey or interview of students to get their feedback on same. Students after exposure to online labs not only have scored better in achievement tests but has also developed better learning attitude towards the subject. Tuysuz (2010) .Not only learning but assessment of science lab with scaffolds methods has been given thumps up by 36 students who worked with Nedungadi et al (2011). CAPS (Computer Assessment of Practical Skills) developed by this team asses experiment's procedural, manipulative and reporting skills. As the experiments are online, repetition and large number of students is not an issue. In other study students have shown better conceptual gains with online labs and found it more encouraging in comparison to traditional lab. Nedungadi et al (2013), Gryczka et al (2014).

Students are hugely benefited by the flexibility of working hours and multiple stimulations provided by online labs which are not possible in traditional lab. In fact most of the students do these online experiments after 6 PM which is out of scope in teaching with traditional lab. Dizabenko et al (2013). In past decade most of the online labs are web based however Arista and Kuswanto (2018) developed an app for physics online labs and student response of learning from this platform was very encouraging. The future of online lab is app based as it is more users friendly and easy to access by both students as well as teachers. From the reviewed literature it is clearly evident that flexibility of repitiation and convinent timings helps students for better understanding of concepts of science.

**Review of existing online lab repositories:**
Online lab Repository is a common platform where online lab video, animations, exercises etc can be found. In present research, a set of thirteen repositories of online labs has been assembled throughout research in related publications and internet sources. These are thoroughly analyzed according to the following dimensions:

- The types of lab included in each repository, namely virtual or remote labs, as well as the number of labs per category.
- These repositories were also searched if they have special sets of labs based on secondary school curriculum.
- To ease navigation for secondary school teachers as well as students these repositories were searched for class wise/age wise categorizations of labs.
- Science can be broadly divided into Physics, chemistry and biology at secondary school level so these repositories were analyzed for subject wise segregation.S.

On the basis of Meta-analysis of online repositories (Table 1) researcher found that out of 13 repositories under study only 8 had labs based on secondary school science curriculum and only two repositories have remote labs. 5 online repositories provide segregation of lab based on class or age. SmartScience, Explore learning and Next science lab are paid repositories so not assessable to large student population. PhET, Explore learning and Next science lab are mainly focused on school curriculum based experiments. Few repositories which are based on appropriate metadata for secondary school education are not freely assessable and those which are free does not justify with requirements for school students and teachers.

**Table 1**

| S. No | Name | Total labs | Remote lab | Virtual lab | Different category for secondary school | Class wise | Lab for Physics of secondary school | Lab for Chemistry of secondary school | Lab for Biology of secondary school |
|---|---|---|---|---|---|---|---|---|---|
| 1. | PhET | 158 | _ | 158 | YES | NO | 72 | 33 | 4 |
| 2. | Library of labs | 274 | _ | 274 | NO | NO | _ | _ | _ |
| 3. | Skoool | 4950 | _ | 4950 | YES | YES | 54 | 86 | 51 |
| 4. | Open source physics | 2000 | _ | 2000 | NO | NO | _ | _ | _ |
| 5. | Smart science | 181 | 181 | --- | YES | YES | 80 | 36 | 44 |
| 6. | Molecular work bench | 946 | – | 946 | NO | NO | 39 | 22 | 12 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 7. | Explore learning | 450 | --- | 450 | YES | YES | 82 | 51 | 71 |
| 8. | Chem.-collective | 126 | --- | 126 | YES | NO | -- | 126 | -- |
| 9. | WebLab Deusto | 15 | -- | 15 | NO | NO | -- | -- | -- |
| 10. | GOLABZ | 625 | 54 | 554 | YES | NO, Age wise | 381 | 98 | 62 |
| 11 | VLAB | 100+ | -- | 100 | NO | NO | -- | -- | -- |
| 12 | ChemVLab+ | 08 | -- | 08 | YES | NO | -- | 08 | -- |
| 13 | Next science lab | 450+ | -- | 50+ | YES | YES | Not disclosed | Not disclosed | Not disclosed |

**V. CONCLUSION:**

Online science labs are an efficient way to fill up the gap between theory and practical learning especially when finances and space are limiting factors. Although Teacher and students both have given positive feedbacks in researches done on online lab efficiency in past decade still lot of work has to be done in this area. Especially there is a need of dedicated free online lab repository based on secondary school curriculum with equal emphasis on physics, chemistry and biology labs.

**REFERENCES:**


I. Aljuhani, Khulood & Sonbul, Marwa & Althabiti, Mashail & Meccawy, Maram. (2018). Creating a Virtual Science Lab (VSL): the adoption of virtual labs in Saudi schools. Smart Learning Environments. 5. 10.1186/s40561-018-0067-9.

II. Al Musawi, Ali & Ambusaidi, Abdullah & Al-Balushi, Sulaiman & Al-Balushi, K. (2015). Effectiveness of E-Lab use in science teaching at the Omani schools. TOJET: The Turkish Online Journal of Educational Technology. 14. 45-52.

III. Arista, F.S.,& Kuswant, H. (2018). Virtual Physics Laboratory Application Based on The Android Smartphone to Improve Learning Independence and Conceptual Understanding. International Journal of Instruction, 11(1), 1-16.

IV. Balakrishnan, Balamuralithara & Woods, Peter. (2009). Virtual laboratories in engineering education: The simulation lab and remote lab. Computer Applications in Engineering Education. 17. 108 - 118. 10.1002/cae.20186.

V. Christian, Maier & Michael, Niederstätter. (2010). Lab2go – A Repository to Locate Online Laboratories. International Journal of Online Engineering. 6. 10.3991/ijoe.v6i1.1117.

VI. Davenport, Jodi & Rafferty, Anna & Yaron, David. (2018). Whether and How Authentic Contexts Using a Virtual Chemistry Lab Support Learning. Journal of Chemical Education. 95. 10.1021/acs.jchemed.8b00048.

VII. de Lima, João Paulo & Mellos Carlos, Lucas & Schardosim Simão, José & Pereira, Josiel & Mafra, Paulo & Silva, Juarez. (2016). Design and implementation of a remote lab for teaching programming and robotics. IFAC-PapersOnLine. 49. 10.1016/j.ifacol.2016.11.133.

VIII. Dikke, Diana & Tsourlidaki, Eleftheria & Zervas, Panagiotis & Cao, Yiwei & Faltin, Nils & Sotiriou, Sofoklis & Sampson, Demetrios. (2014). GOLABZ: TOWARDS A FEDERATION OF ONLINE LABS FORINQUIRY-BASED SCIENCE EDUCATION AT SCHOOL

IX. Dziabenko, O. & Orduña, Pablo & Garcia-Zubia, Javier. (2013). Remote experiments in secondary school education. Proceedings - Frontiers in Education Conference. 1760-1764. 10.1109/FIE.2013.6685140.

X. Gomes, Luis & Bogosyan, Seta. (2010). Current Trends in Remote Laboratories. Industrial Electronics, IEEE Transactions on. 56. 4744 - 4756. 10.1109/TIE.2009.2033293.

XI. Gryczka, Patrick & Klementowicz, Edward & Sharrock, Chappel & Montclare, Jin. (2016). Interactive online physics labs increase high school students' interest. Journal of Technology and Science Education. 6. 166. 10.3926/jotse.191.

XII. Jihad, Teeba & Klementowicz, Edward & Gryczka, Patrick & Sharrock, Chappel & Maxfield, Macrae & Lee, Yougjun & Montclare, Jin. (2018). Perspectives on blended learning through the on-line platform, LabLessons, for Chemistry. Journal of Technology and Science Education. 8. 34. 10.3926/jotse.312.

XIII. Lynch, Tiina & Ghergulescu, Ioana. (2017). NEWTON Virtual Labs: Introduction and Teacher Perspective. 343-345. 10.1109/ICALT.2017.133.

XIV. Nedungadi, Prema & Raman, Raghu & McGregor, Mark. (2013). Enhanced STEM learning with Online Labs: Empirical study comparing physical labs, tablets and desktops. Proceedings - Frontiers in Education Conference. 1585-1590. 10.1109/FIE.2013.6685106.

XV. Raman, Raghu & Haridas, Mithun & Nedungadi, Prema. (2015). Blending Concept Maps with Online Labs for STEM Learning. Advances in Intelligent Systems and Computing. 320. 133-141. 10.1007/978-3-319-11218-3_14.

XVI. Sampson, Demetrios & Tsourlidaki, Eleftheria & Zervas, Panagiotis & Sotiriou, Sofoklis. (2015). Towards a Metadata Schema for Characterizing Lesson Plans Supported by Remote and Virtual Labs for School Science Education.

XVII. Son, Ji & Narguizian, Paul & Beltz, Dwight & Desharnais, Robert. (2016). Comparing Physical, Virtual, and Hybrid Flipped Labs for General Education Biology. Online Learning. 20. 228-243. 10.24059/olj.v20i3.687.

XVIII. Tuysuz, Cengiz. (2010). The Effect of the Virtual Laboratory on Students' Achievement and Attitude in Chemistry. International Online Journal of Educational Sciences. 2.